Construction of the detail 3D velocity structure models

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- 1　objectives and character of the model.
- 2　Deep subsurface structure model

  2-1.modeling methods and used data : 0th-order geological model.

  2-2. modifying the model : 1st-order model.
- 3　Shallow subsurface structure model
- 4　conclusions and problems

Objective of the Deep subsurface structure Model

Headquarters for Earthquake Research Promotion (HERP)

National Research Institute for Earth Science and Disaster Prevention (NIED)
Earth Research Institute of Tokyo Univ. etc…

Observed waveform data (K-NET, KiK-net etc…) →

Seismic Faults data →

←3D Deep subsurface structure model

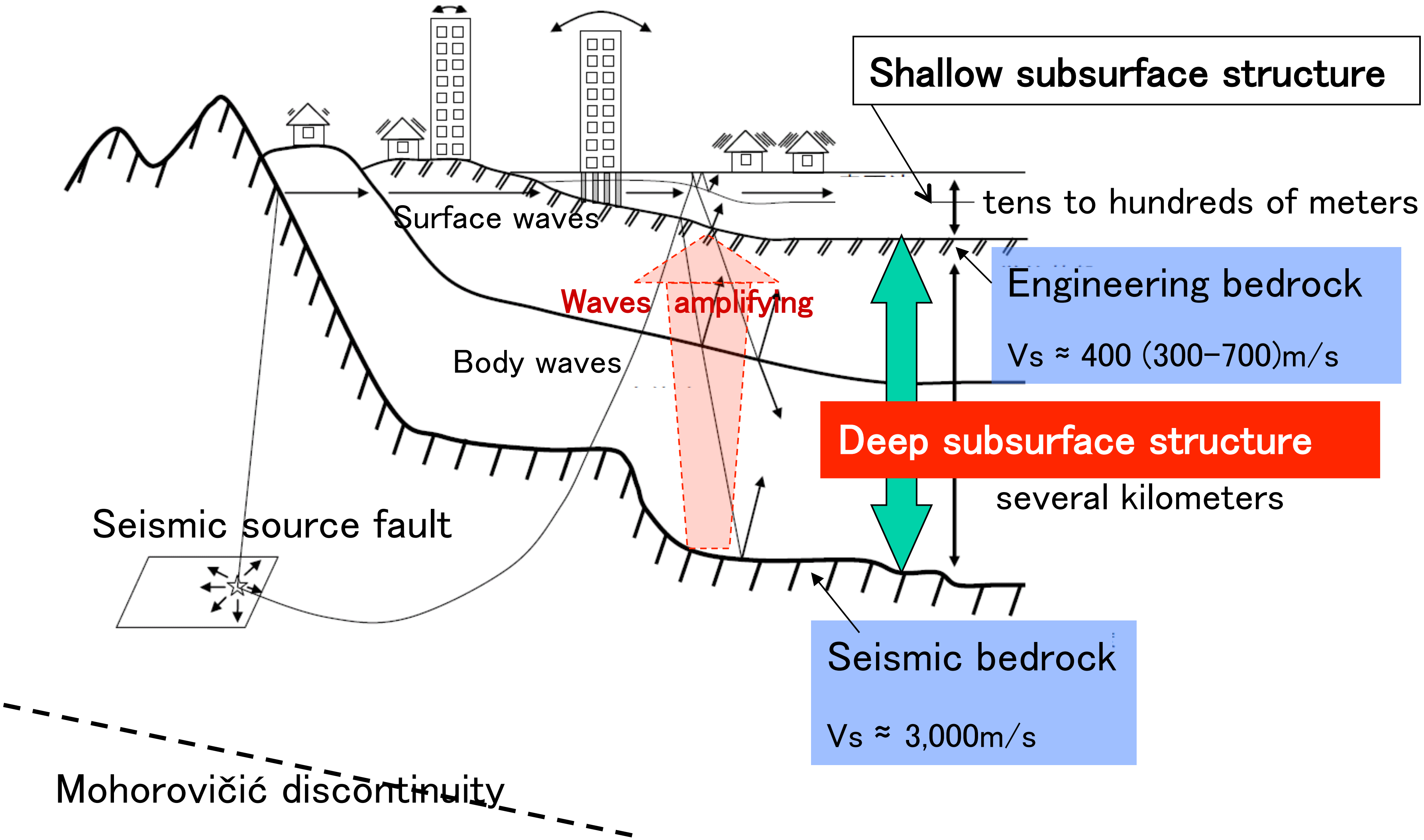
Seismic Hazard Analysis

Probabilistic Seismic Hazard Maps (PSHMs) etc…

→ on the Web : J-SHIS (Japan Seismic Hazard Information Station)

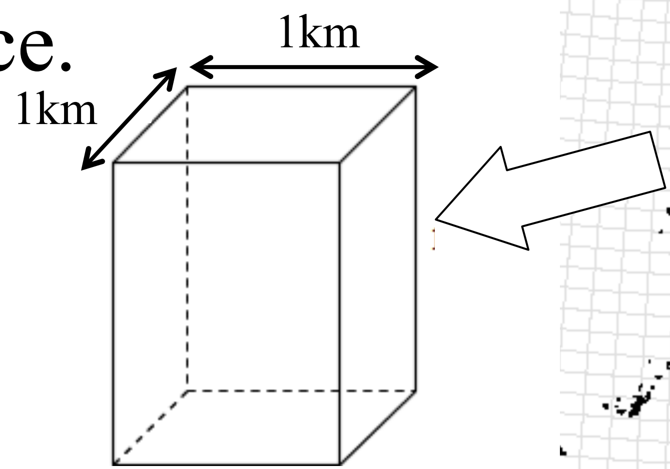
"strengthening disaster prevention measures, particularly for the reduction of damage and casualties from earthquakes "

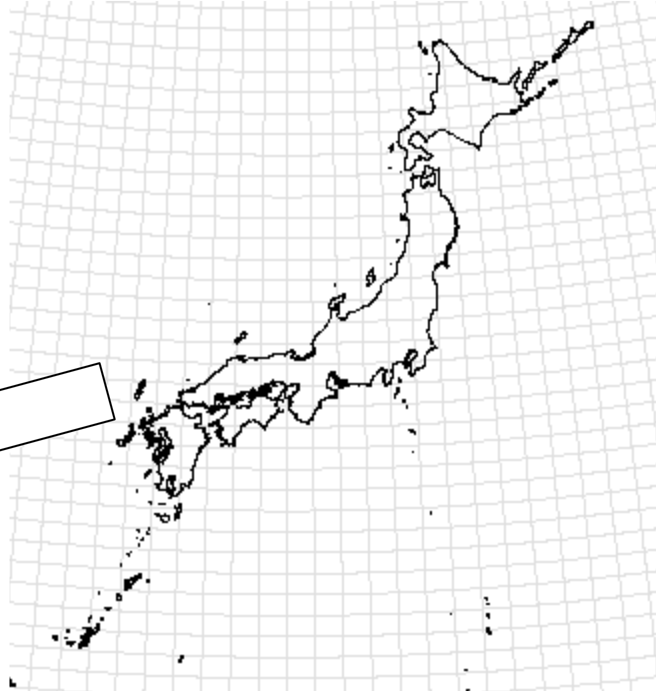
Schematic overview of the subsurface structure models



Outlines of
3D Deep subsurface structure model

- Based on geological data and geophysical exploration data.
- Composed of different seismic velocity layers.
- Vertically divided into cubes with about 1km mesh surface.





Flow chart of modeling the Deep subsurface structure models

Subsurface structure data
- Deep borehole, Logging
- Seismic reflection , refraction survey
- Micro tremor survey
- Gravity survey

Surface geological data
- Topographical Map
- Geological Map

↓

Distribution of physical properties
- Seismic wave velocity
- Density

Structure of Sedimentary layers
- depth
- thickness
- faluts
- folds

↓

Layered structure model of physical property
(0th-order geological model)

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Model modification compared to observed waveform data

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Simulation of seismic waveform using the Layered Model

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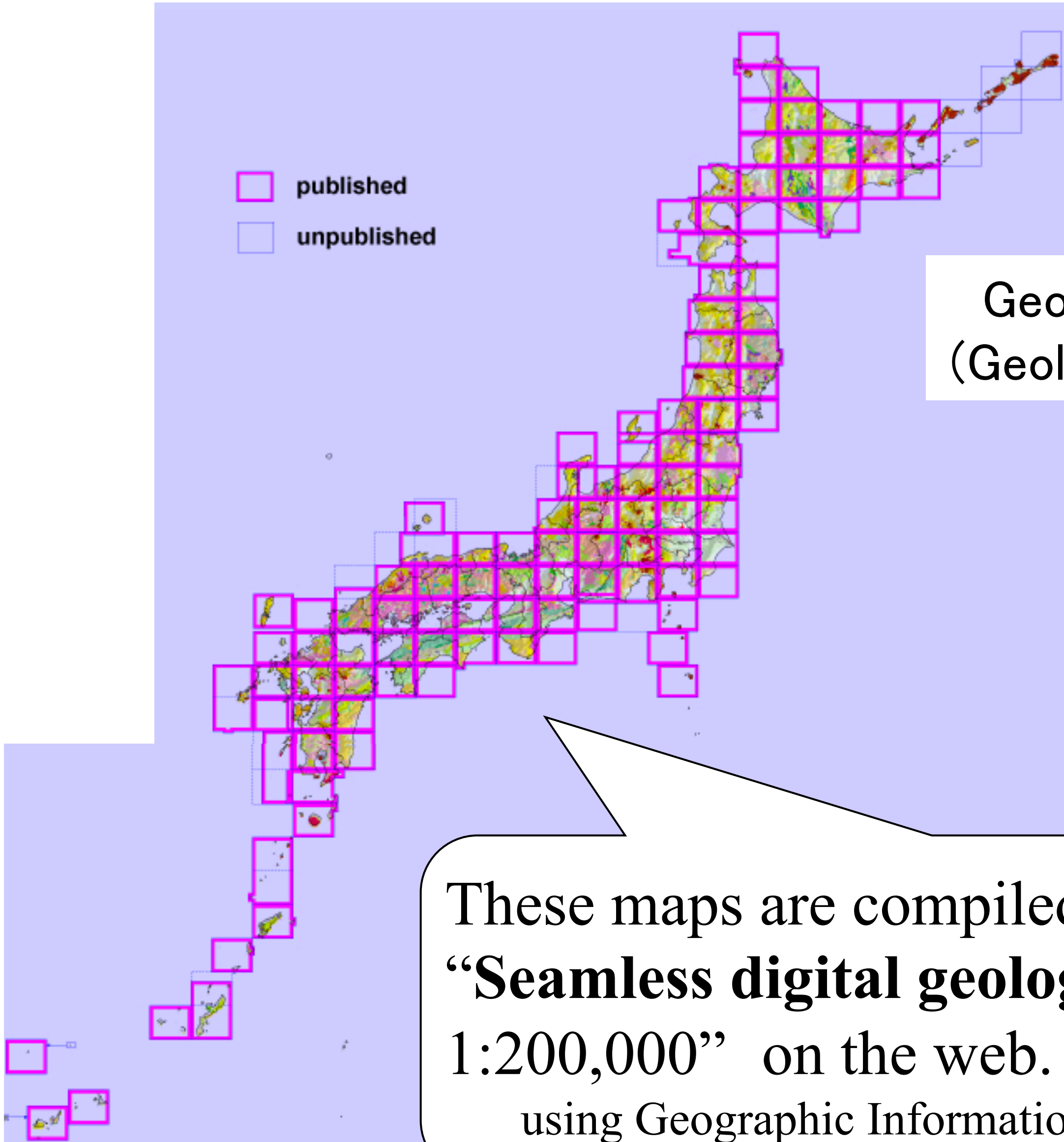
Deep subsurface structure model for Strong-motion Evaluation
(1st-order model)

Surface geological data(1)

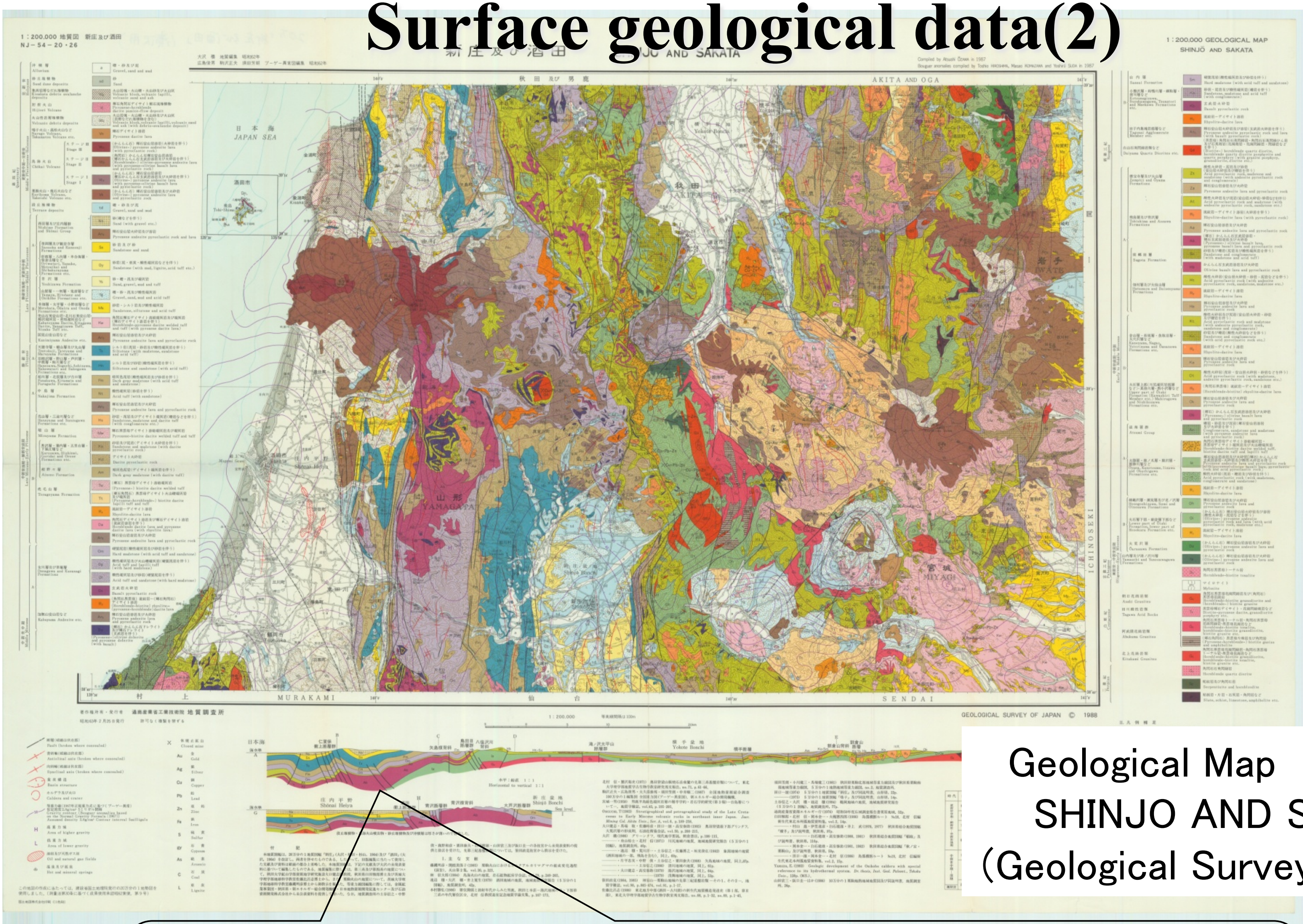


Geological Map 1:200,000
(Geological Survey of Japan)

Foundation of
a geological model

These maps are compiled as
"**Seamless digital geological map** of Japan
1:200,000" on the web.
using Geographic Information System (GIS) software.

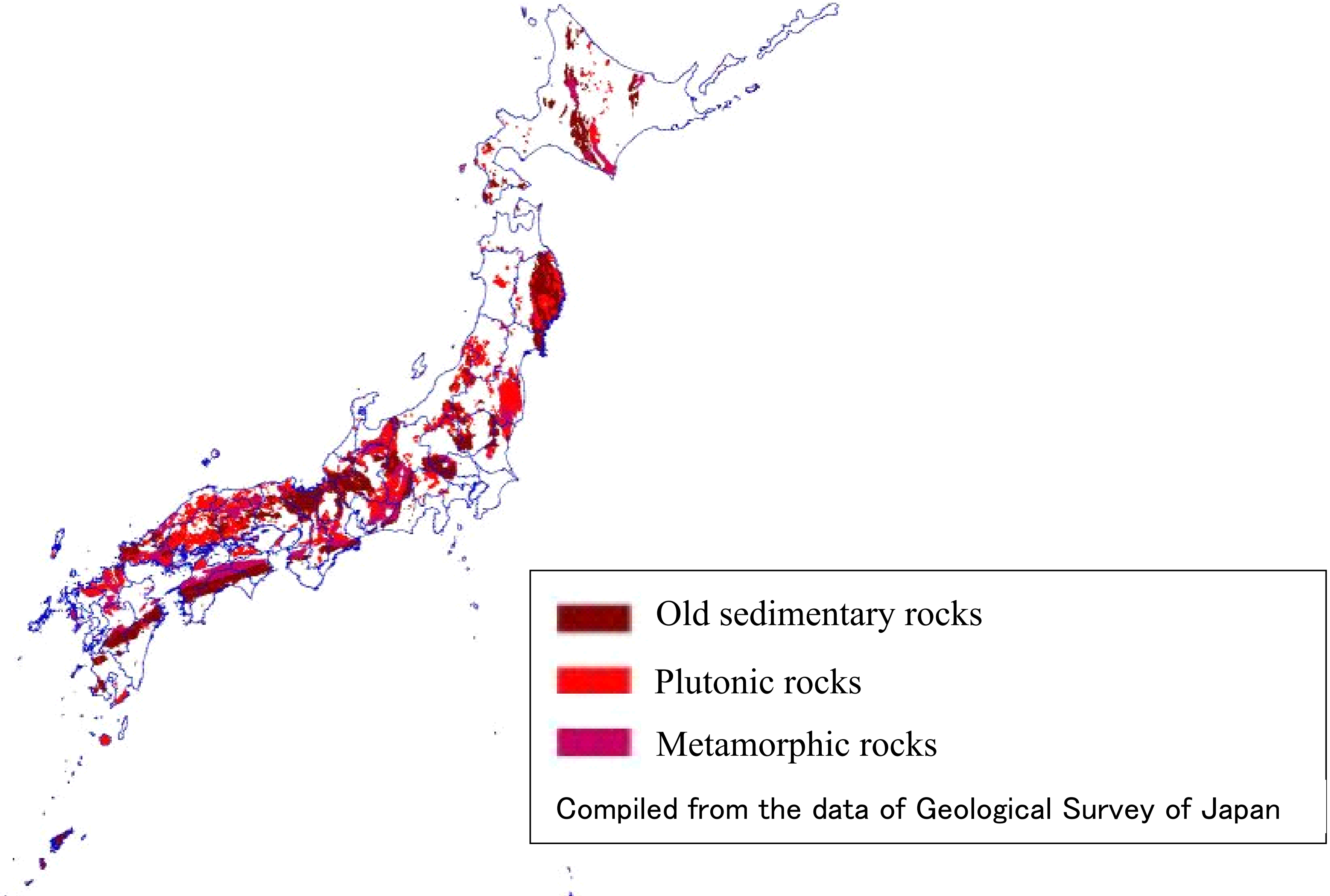
Surface geological data(2)



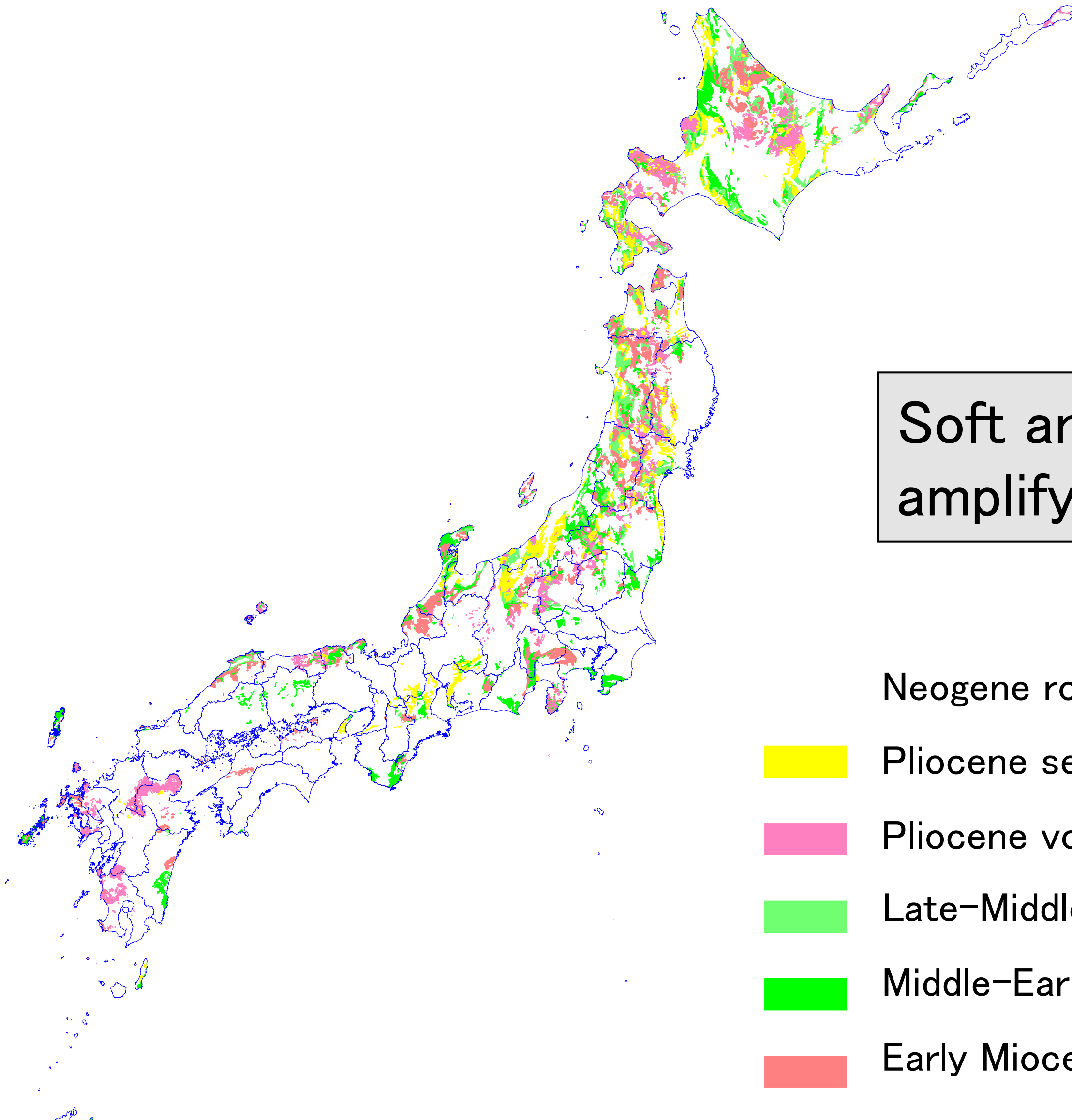
Geological Map 1:200,000
SHINJO AND SAKATA
(Geological Survey of Japan)

In some areas, we can use deep geological profiles down to 5,000m depth based on deep borehole.

Surface geological data(3)
<Surface distribution of seismic bedrock >



Surface geological data(4)
<Surface distribution of sedimentary rocks>

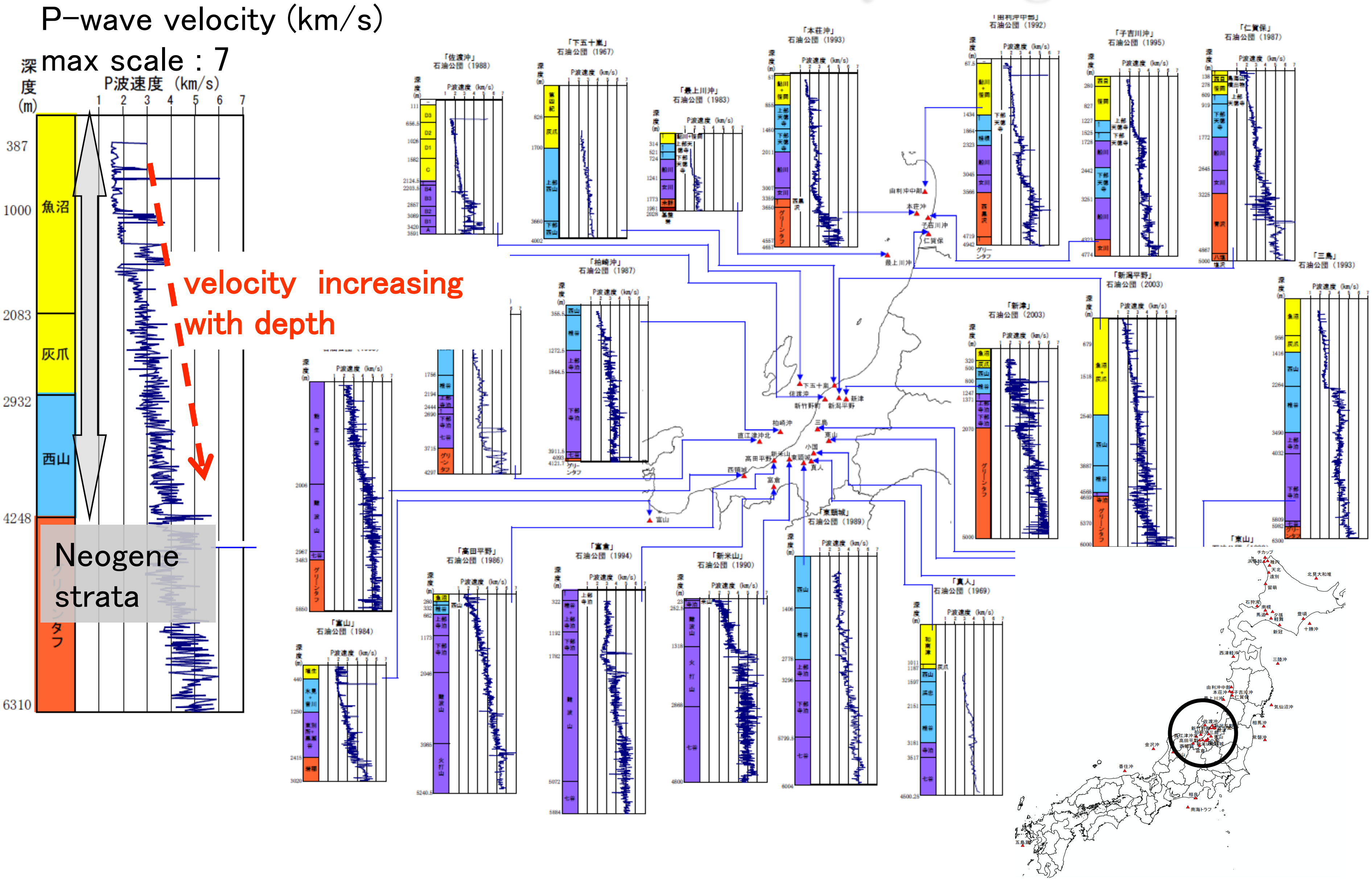


Soft and low S-velocity , amplifying seismic waves

Neogene rocks

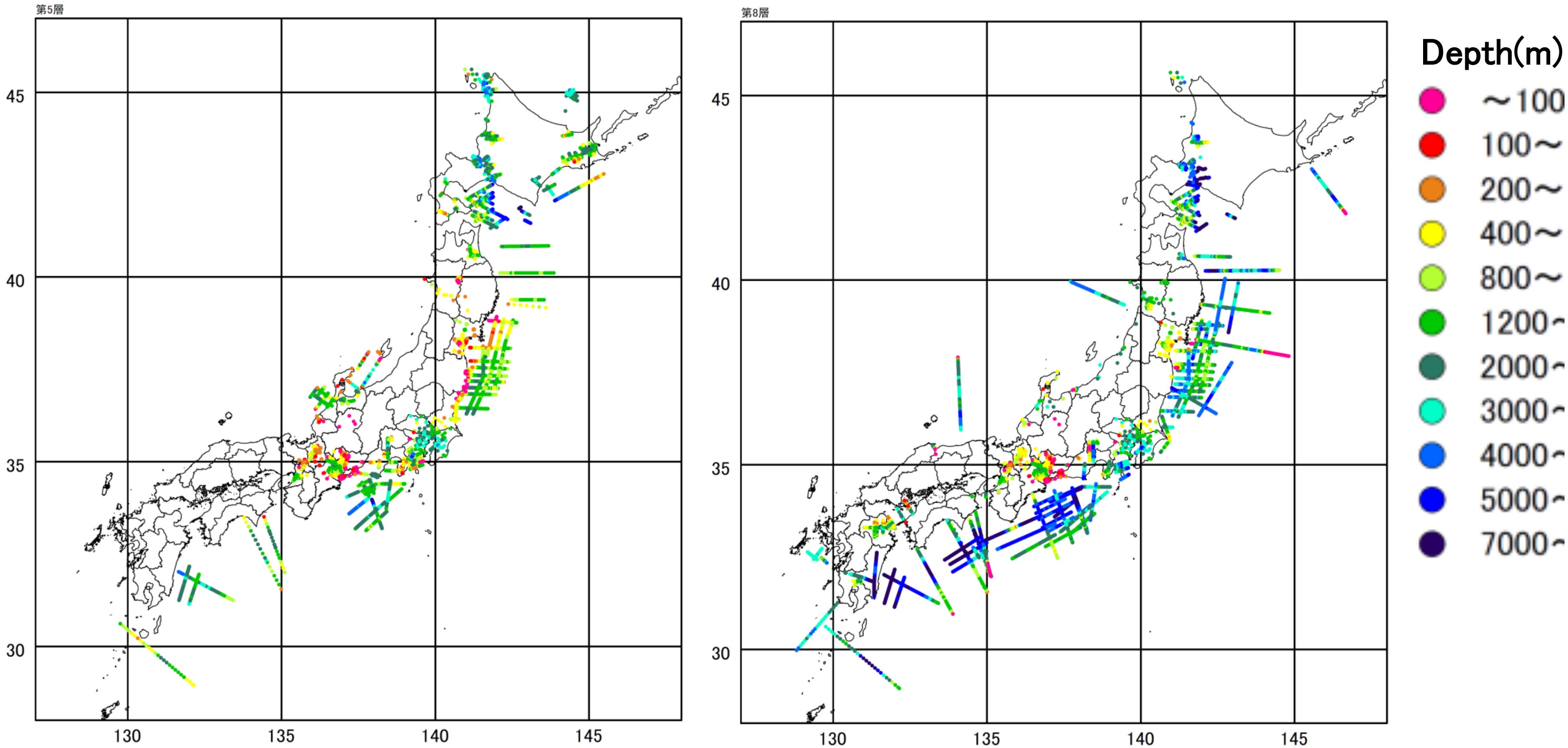
- Pliocene sedimentary rocks
- Pliocene volcanic rocks
- Late-Middle Miocene sedimentary rocks
- Middle-Early Miocene sedimentary rocks
- Early Miocene sedimentary rocks

Deep borehole and seismic logging data
<Borehole and P-wave velocity : Niigata area>



Depth distribution from seismic survey

Depth distribution of the upper surface of example layers



Layer no.5 (Vs2.1km/s) upper surface

Upper surface of the seismic bedrock

Data of "Japan Oil, Gas and Metals National Corporation (JOGMEC)", "the Deep subsurface survey project" by HERP, "Japan Agency for Marine- Earth Science and Technology (JAMSTEC)" and others.

Flow chart of modeling the Deep subsurface structure models

Subsurface structure data
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Surface geological data
- Topographical Map
- Geological Map

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Distribution of physical properties
- Seismic wave velocity
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Structure of Sedimentary layers
- depth
- thickness
- faults
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Layered structure model of physical property
(0th-order geological model)

↓

Model modification compared to observed waveform data

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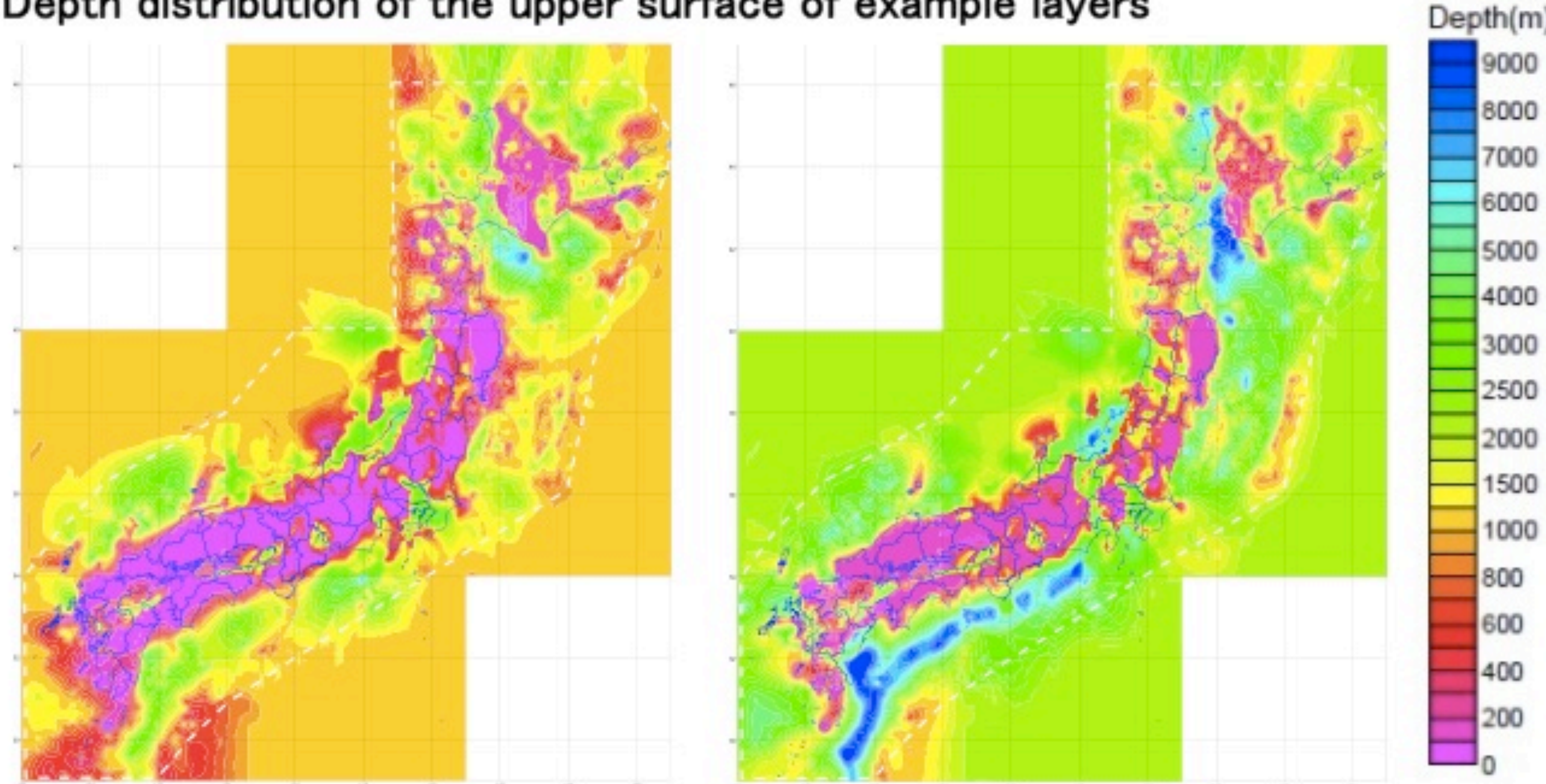
Simulation of seismic waveform using the Layered Model

↓

Deep subsurface structure model for Strong-motion Evaluation
(1st-order model)

0th-order geological model(1)

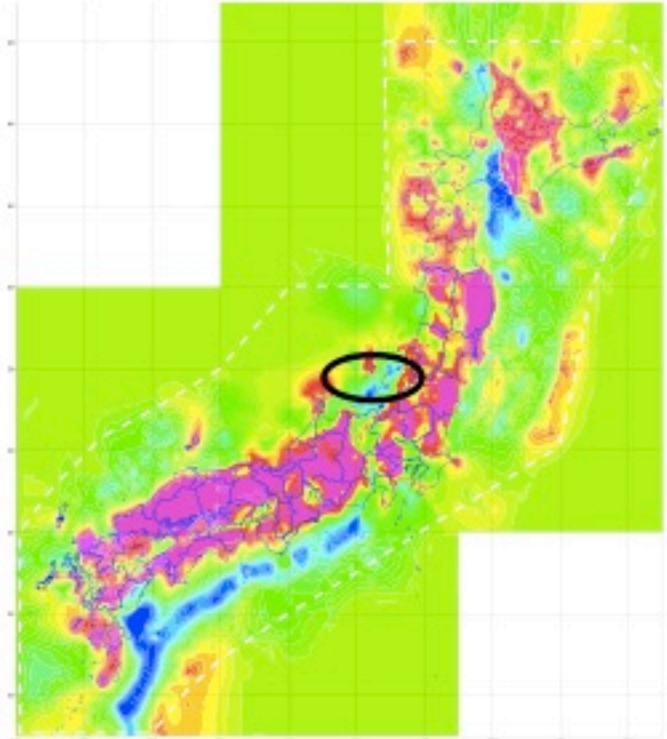
Depth distribution of the upper surface of example layers



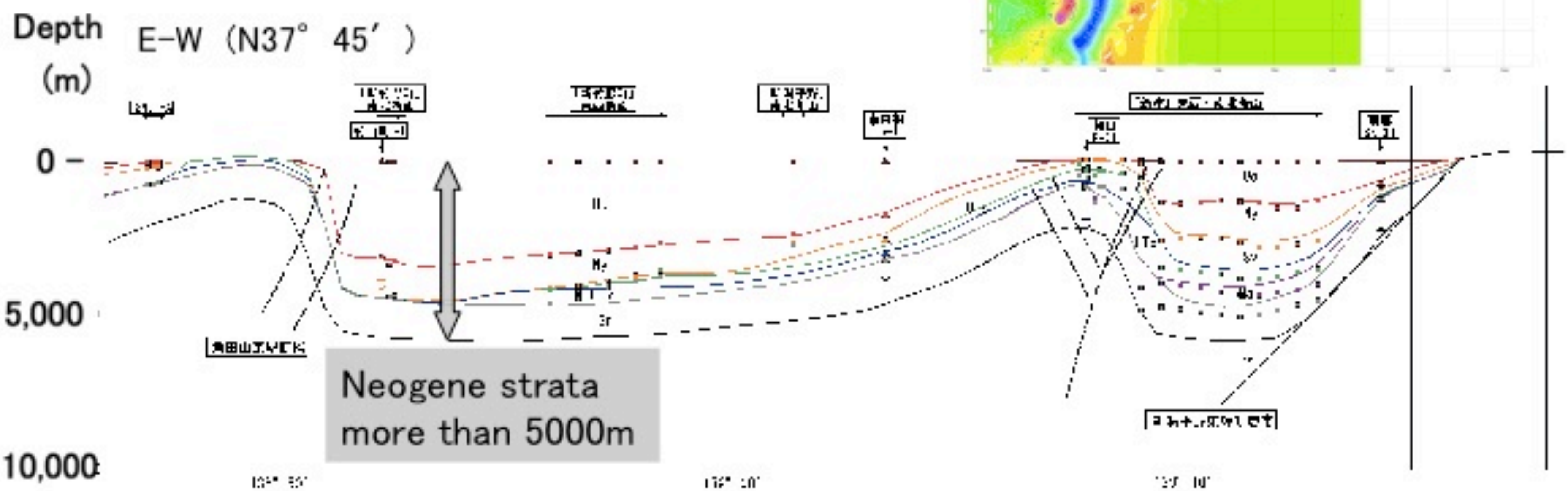
Upper surface of layer of Vs=2.1km/s

Upper surface of the seismic bedrock

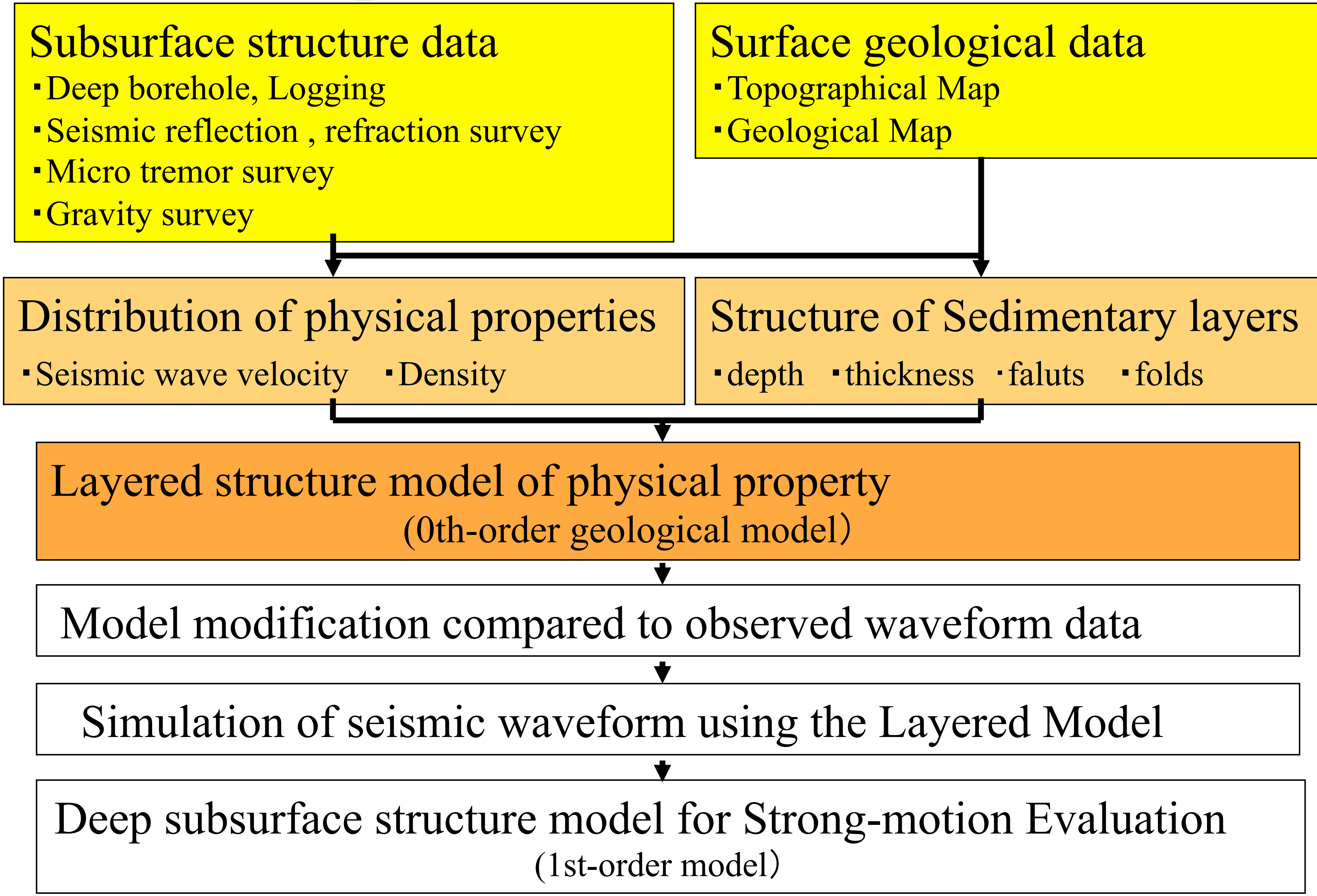
0th-order geological model(2)



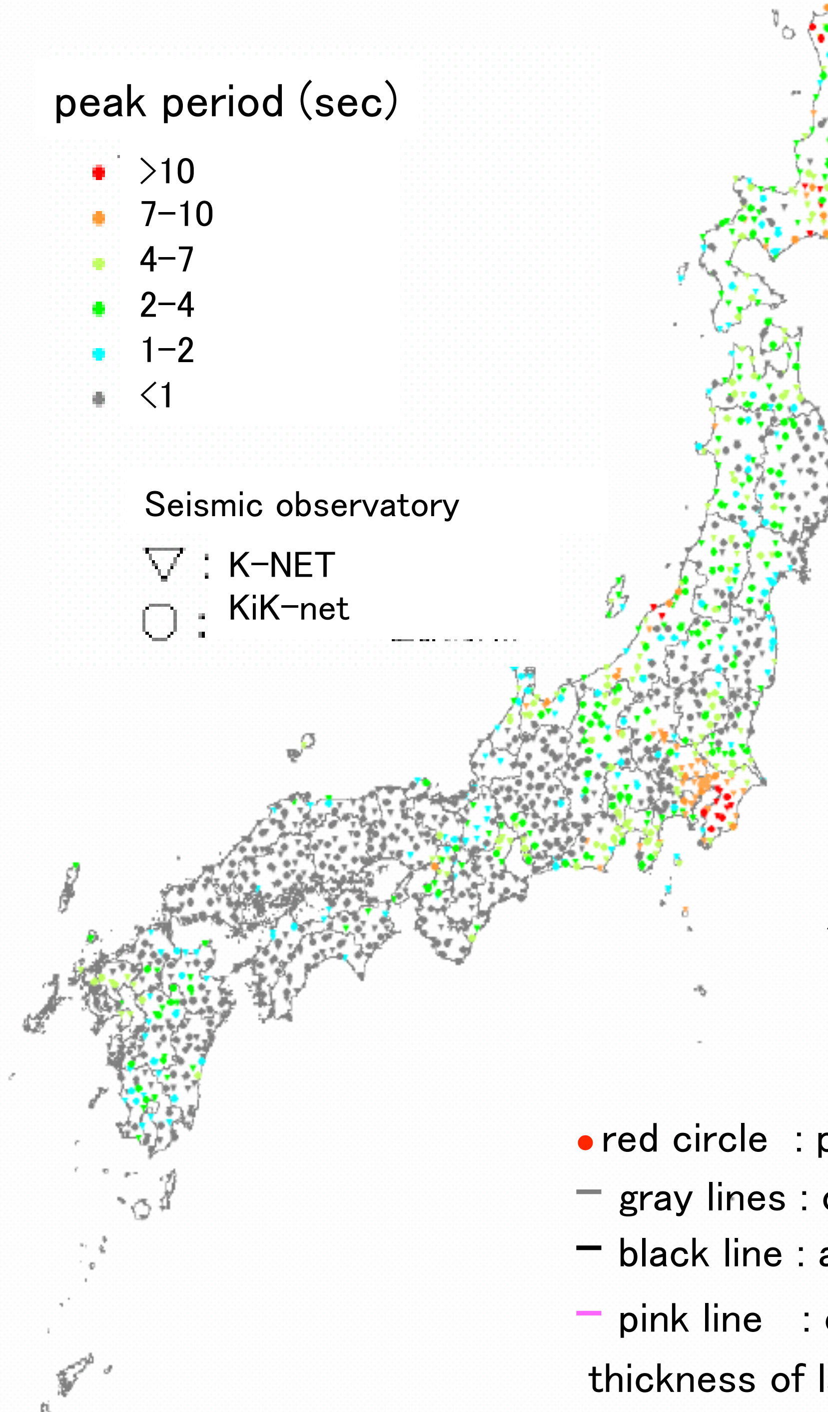
Geological Profile in Niigata area

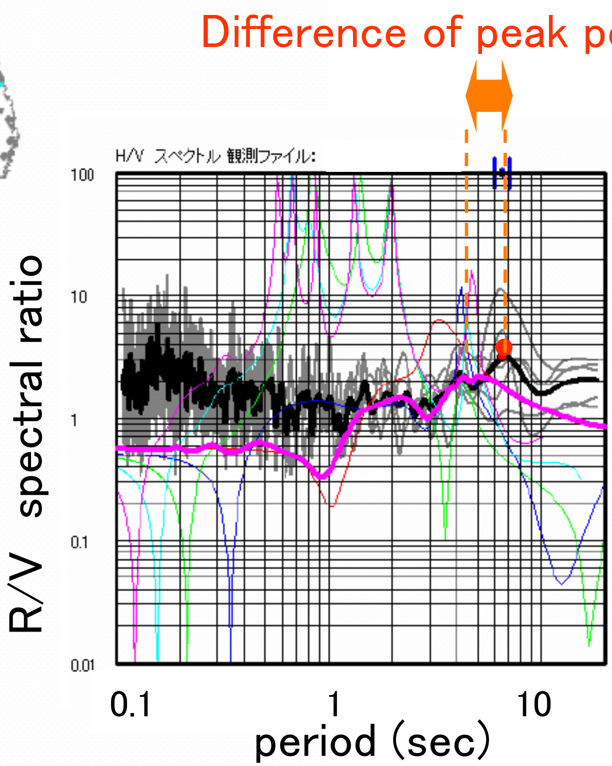


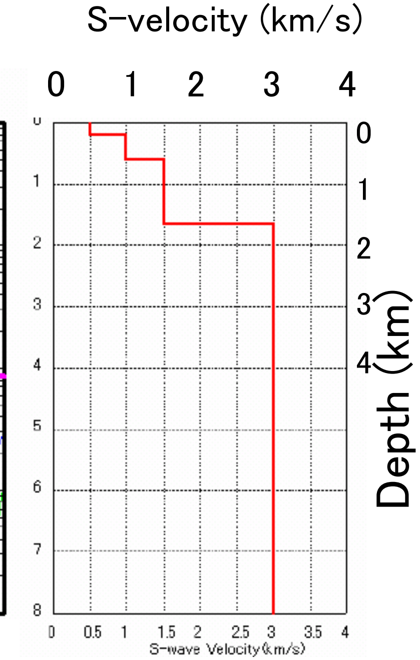
Flow chart of modeling the Deep subsurface structure models



Peak-period of observed R/V spectral ratio







● red circle : peak period of average observed R/V spectral ratio

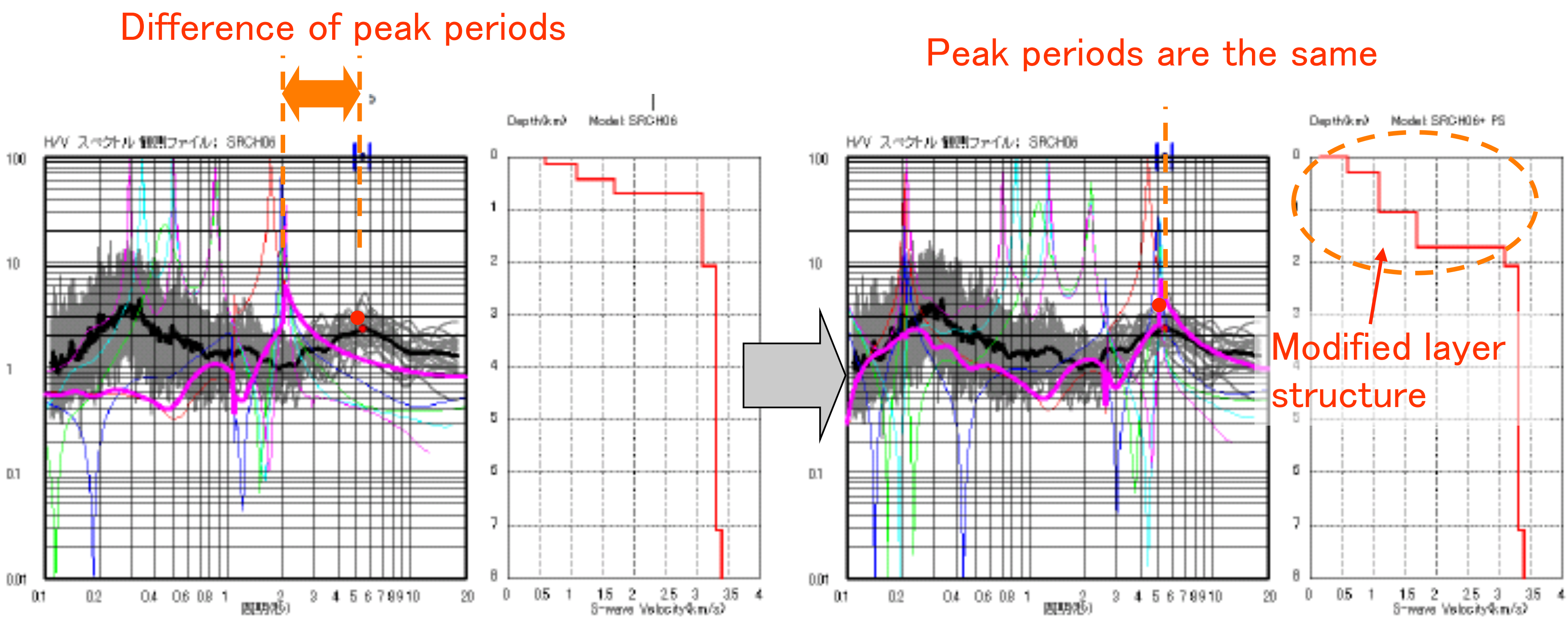
— gray lines : observed R/V spectral ratios

— black line : average observed R/V spectral ratio

— pink line : calculated H/V spectral ratio based on Vs and thickness of layers of the 0th-order geological model (right figure)

Model modification by comparison of observed R/V and model-calculated H/V spectral ratios (1)

Example : Hokkaido area

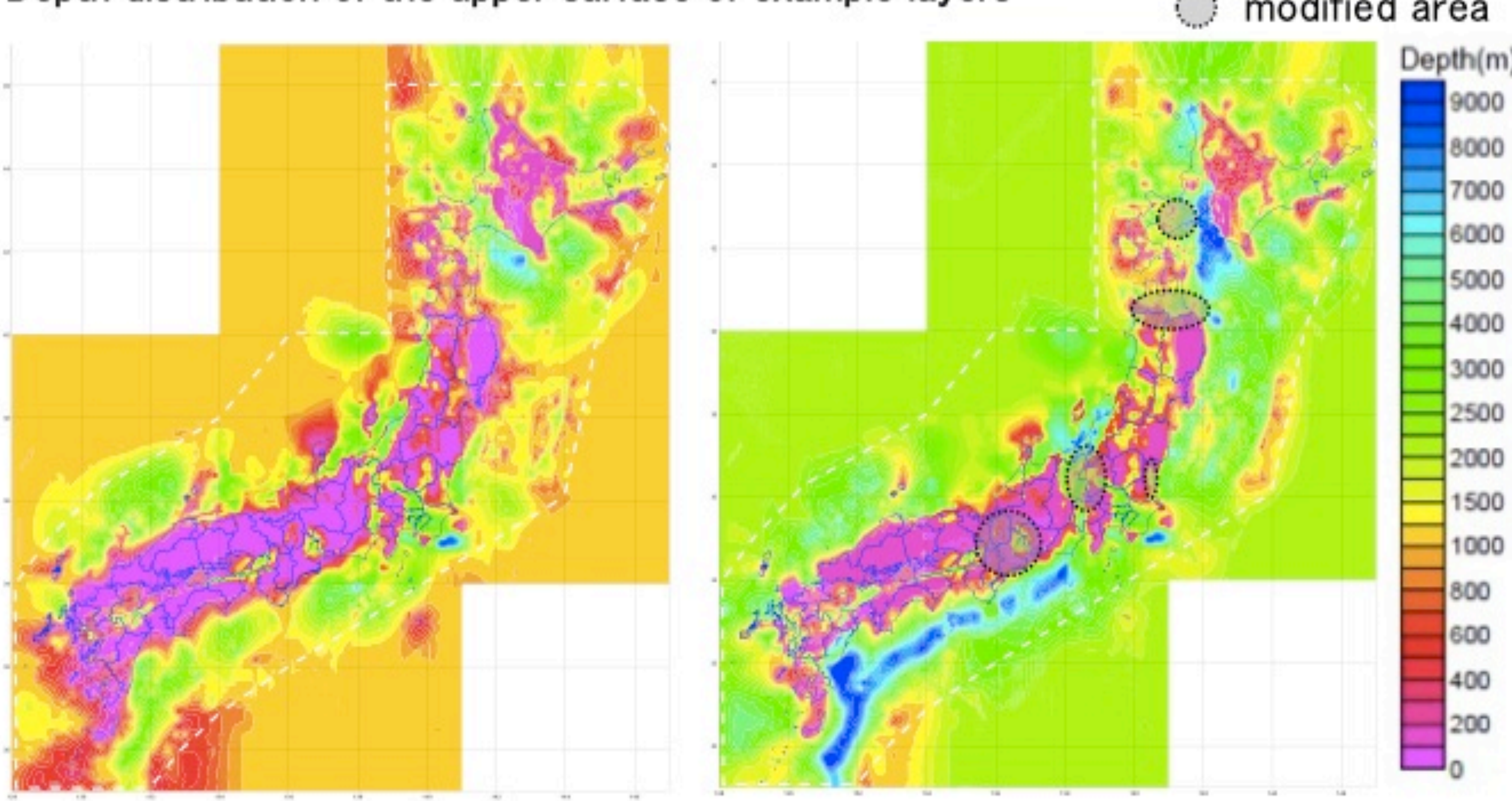


0th-order geological model

Modified model

1st-order velocity layered model(1)

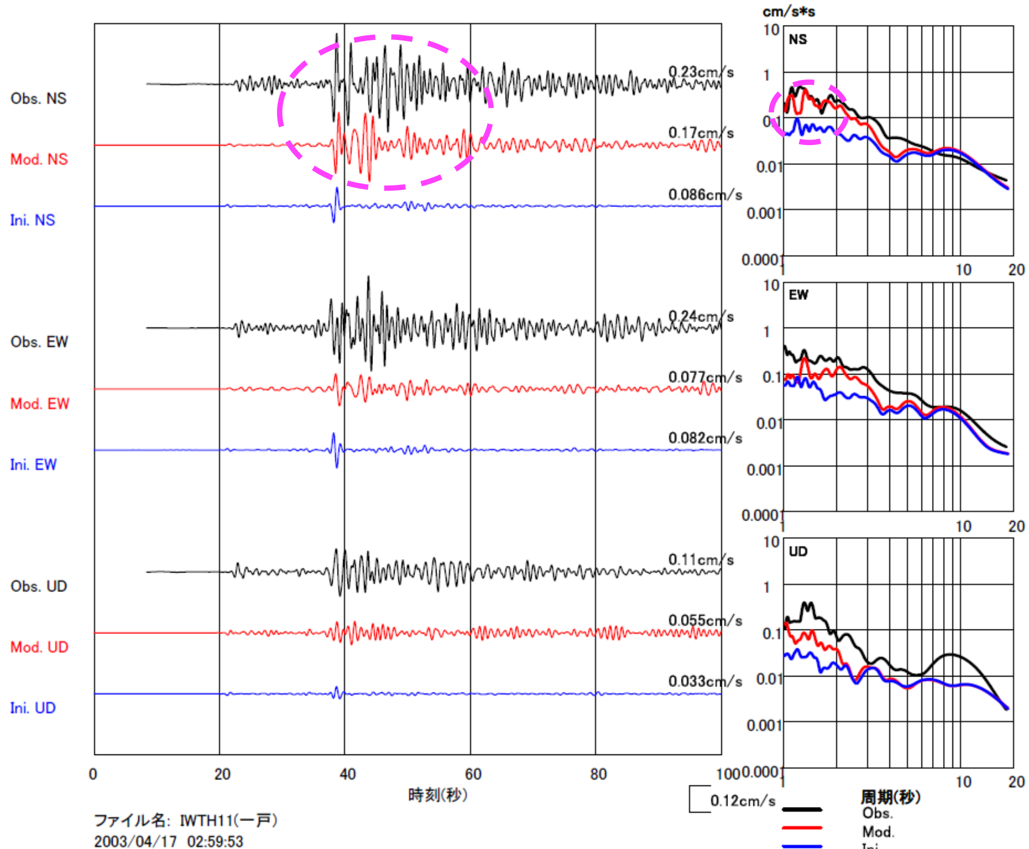
Depth distribution of the upper surface of example layers



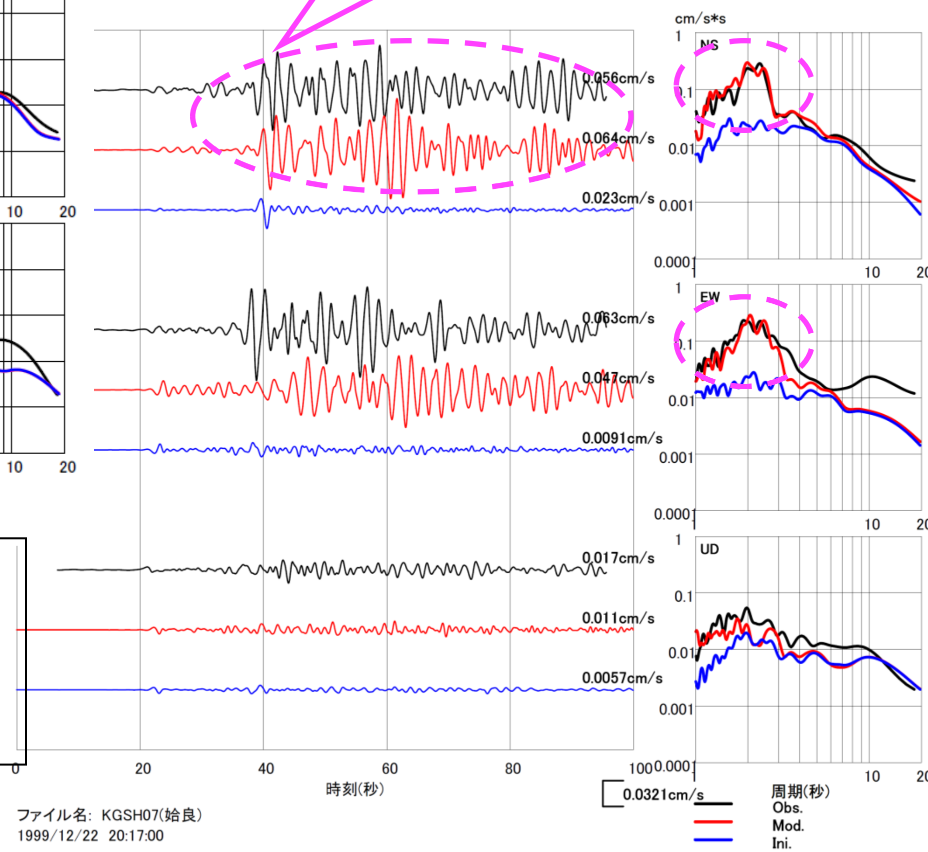
Upper surface of the layer *No.25* (Vs = 2.1km/s)

Upper surface of the seismic bedrock (Vs > 3.1km/s)

Comparison between observed and calculated waveforms using the 0th-order, 1st-order models

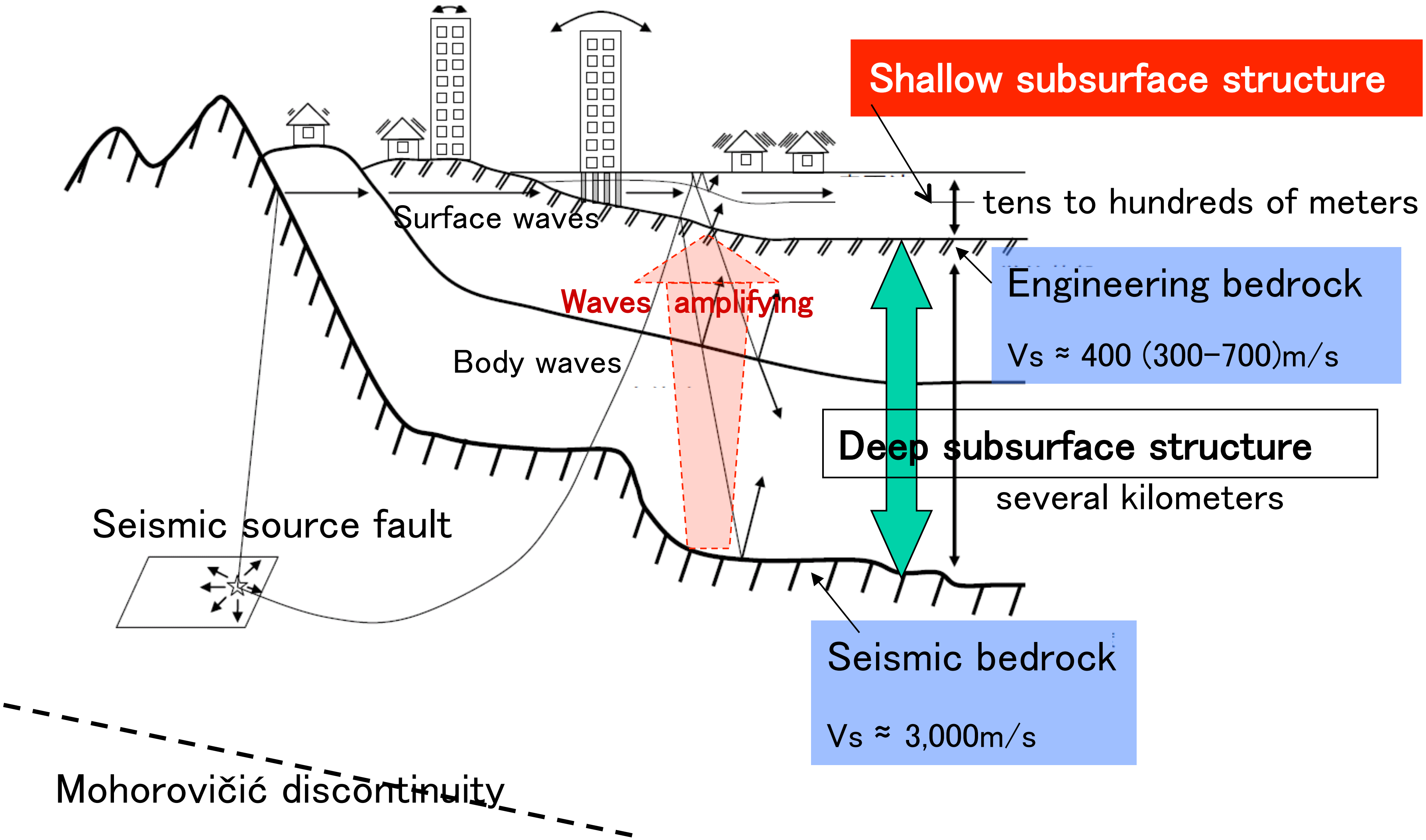


Good correspondence !



- black line : observed waveforms
- red line : calculated waveforms using 1st-order model
- blue line : calculated waveforms using 0th-order model

Schematic overview of the subsurface structure models



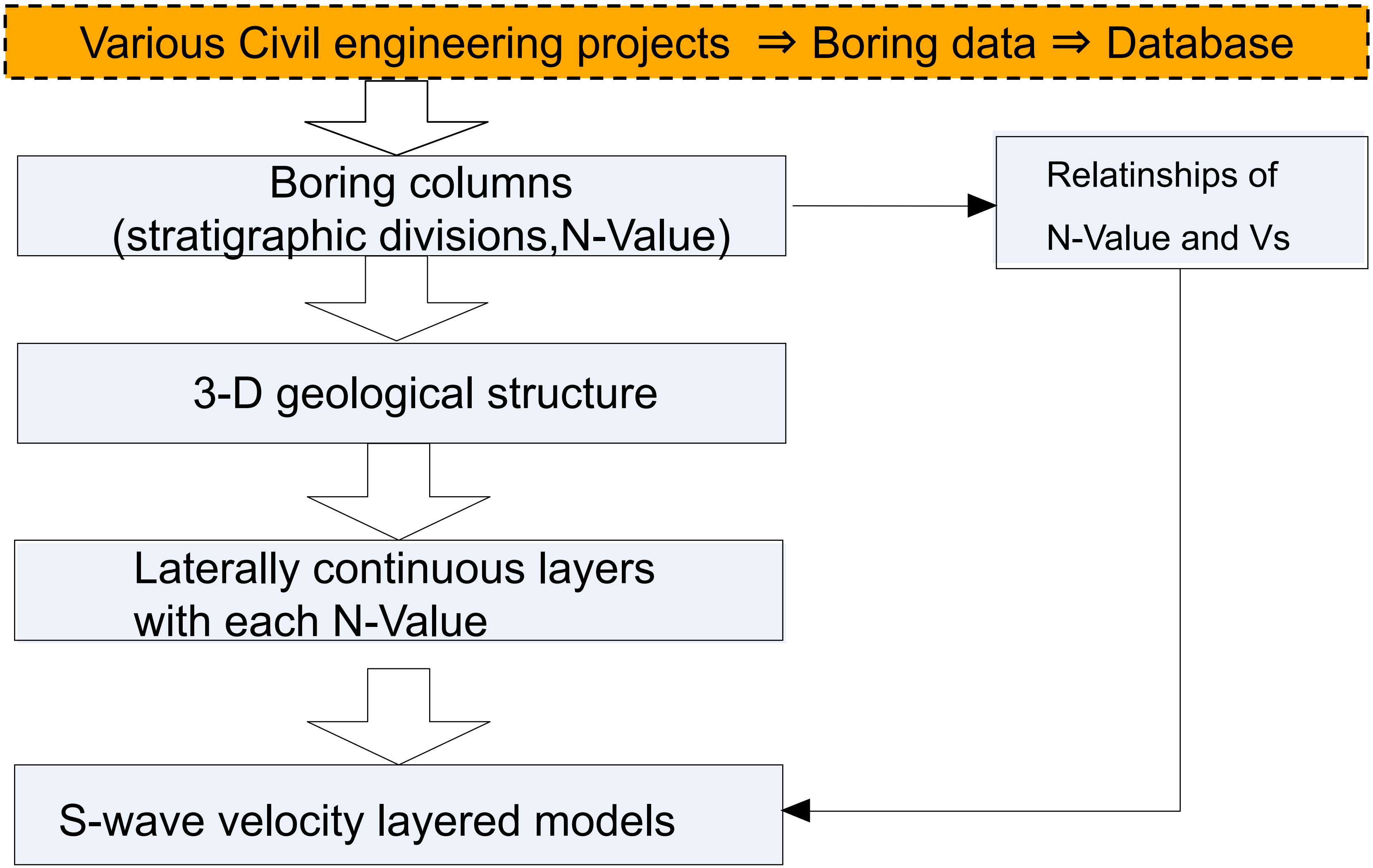
Outlines of
3D Shallow subsurface structure Models

- Various methods for making Models.

Conventional method
using geomorphologic classifications
:J-SHIS (250m grid)

Detailed methods
using a lot of boring data
:recent NIED projects (250m grid)

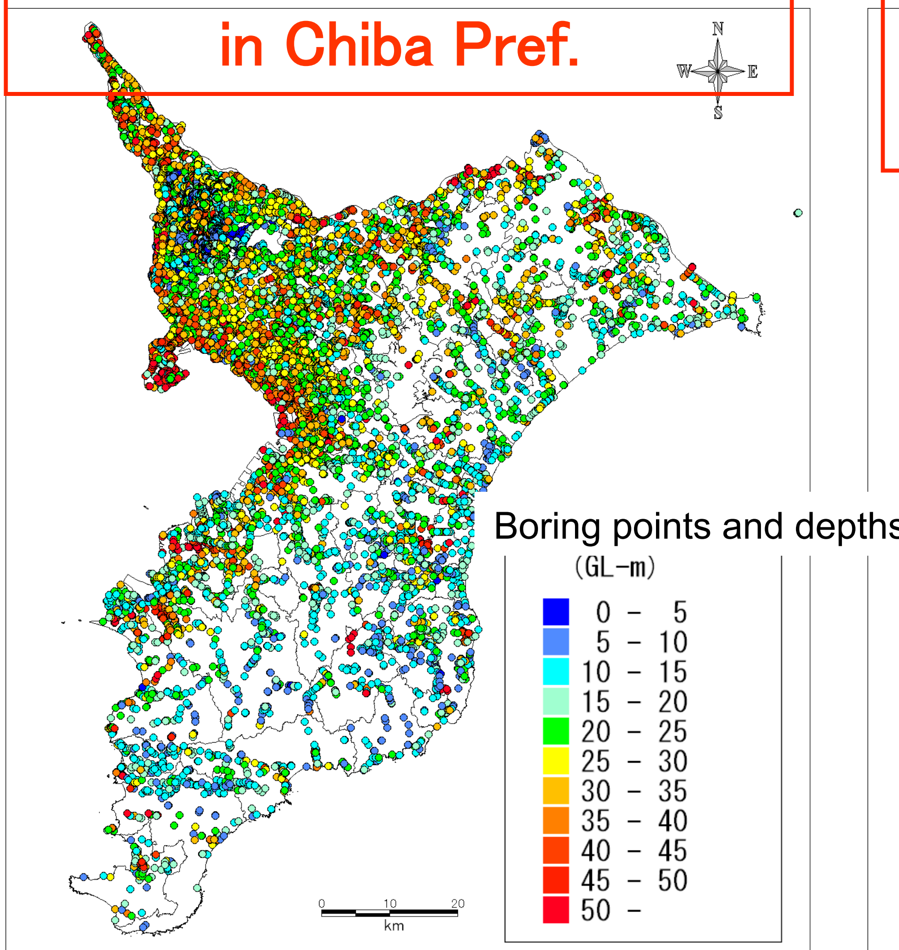
Flow chart of modeling the Shallw subsurface structure models



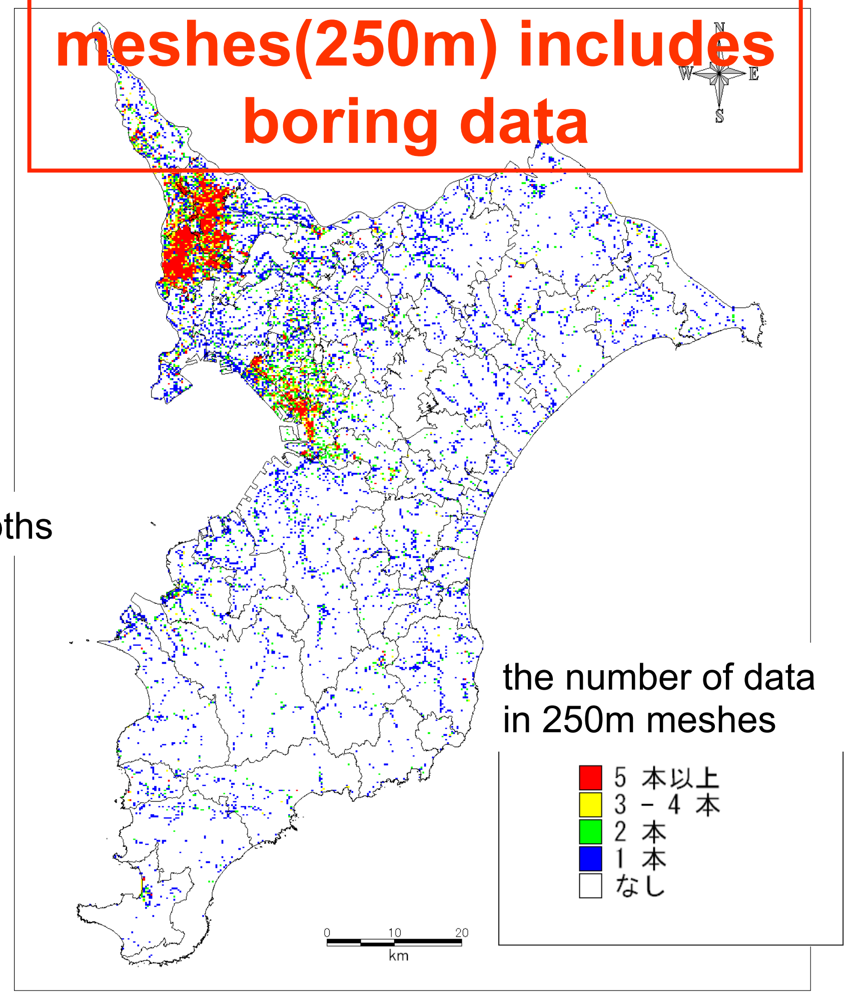
Boring Database of NIED

:about 400 thousands of geological column data

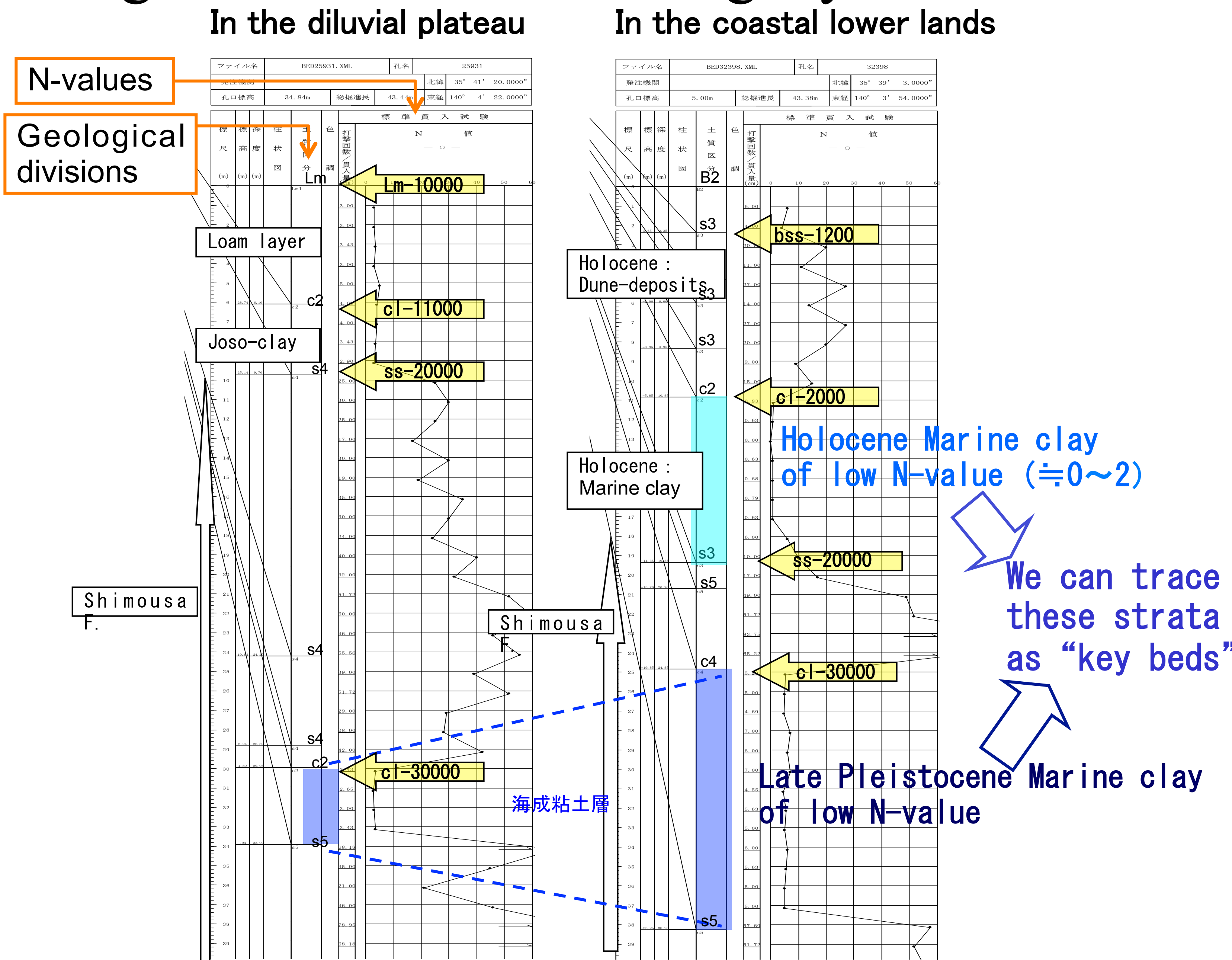
27 thousands data in Chiba Pref.



10 thousands meshes(250m) includes boring data



Gological columns : detecting layer-boundaries



Divisions of strata

Holocen sediments

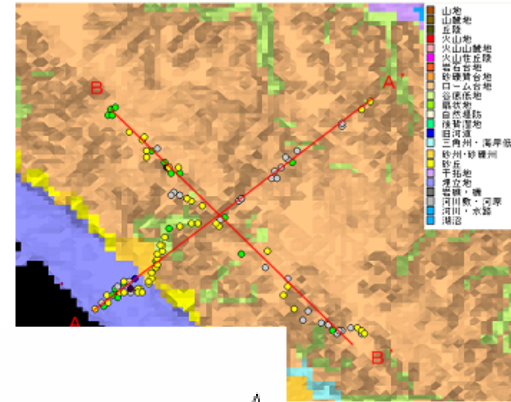
	Sedimentary facies	Main deposits
Upper	topsoil, landfill	sand, silt
	modern river	sand, silt
	dune, beach	sand
middle	delta-front, pro-delta	sand, silt
	marine	clay, silt
	sand bar	sand
lower	meandering river	sand, silt
	braided river	gravel, sand

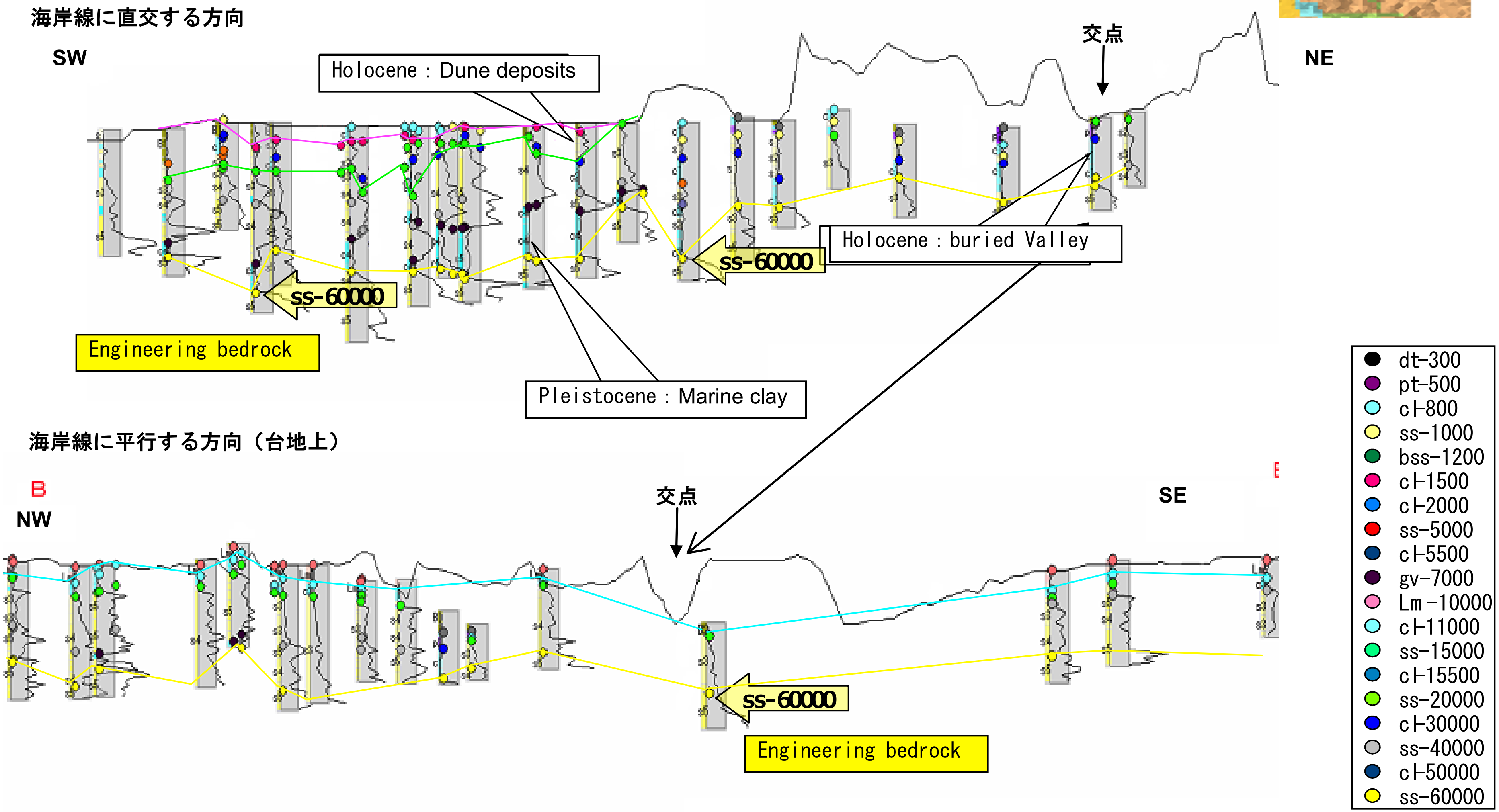
Pleistocene sediments

Geological divisions	Main deposits
Kanto Loam	volcanic ash, clay
Joso Clay	clauey deposits
Shimousa F.	fluvial sand, garvel
	marine clay
	sand
Kazusa F.	alternations of sandy and clayey layer

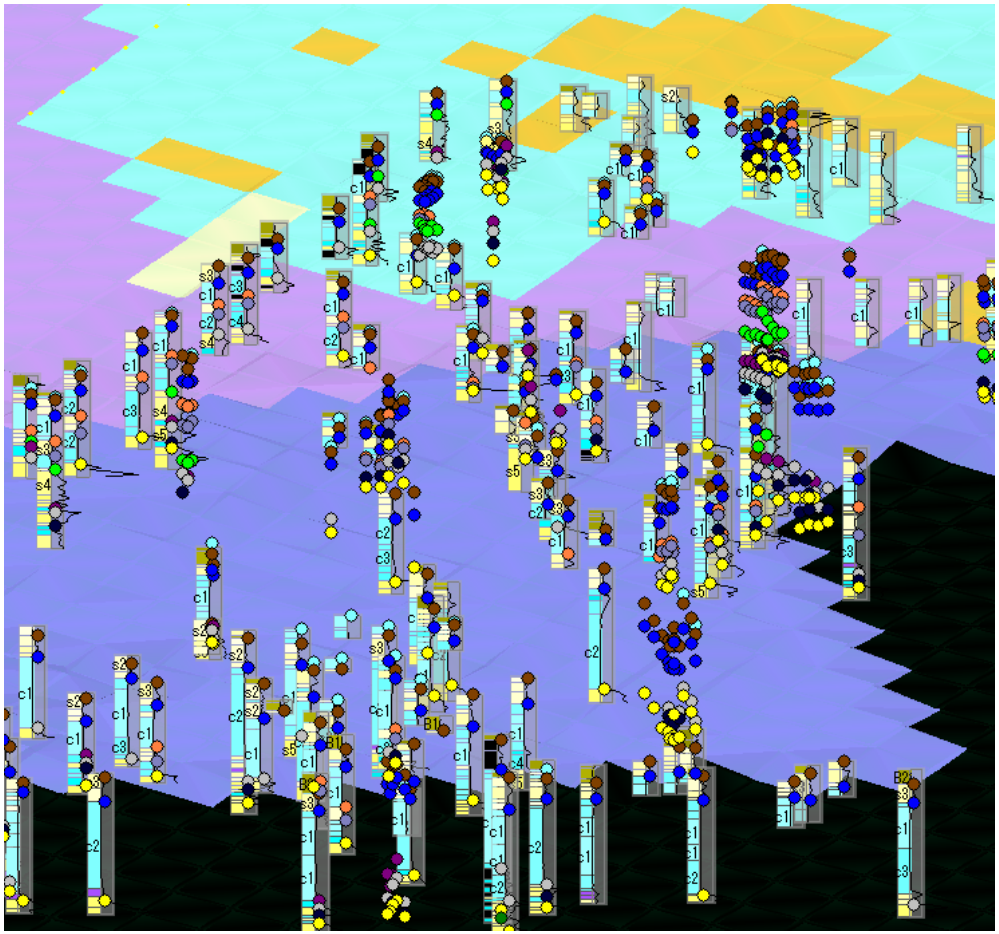
Engineering bed rocks : N>>50

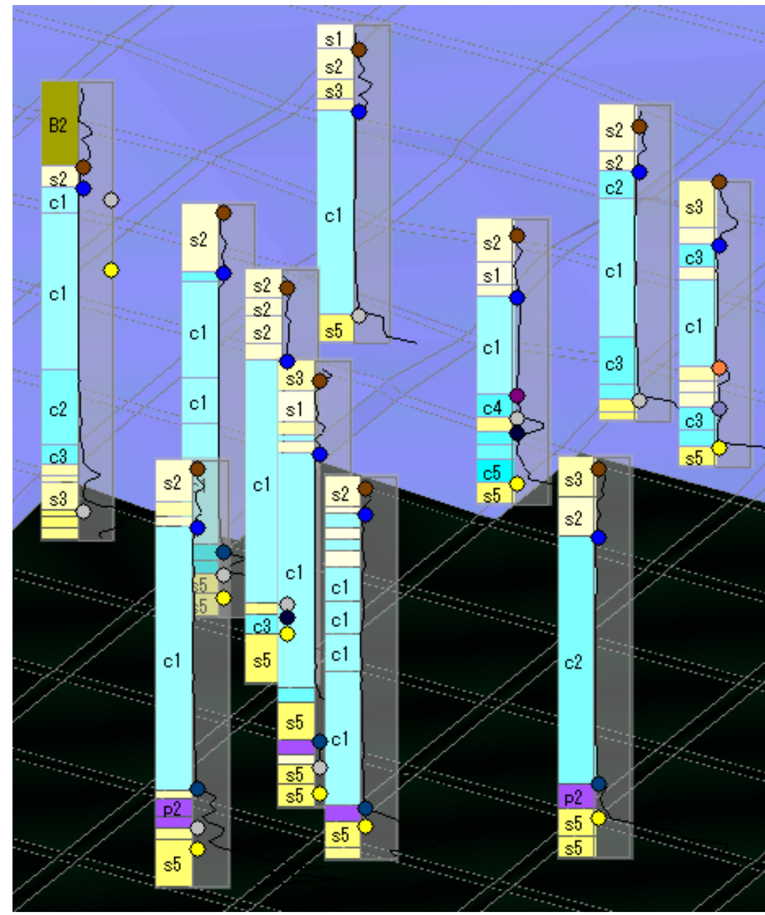
Tracing each stratum and profiling in 2-Dimension





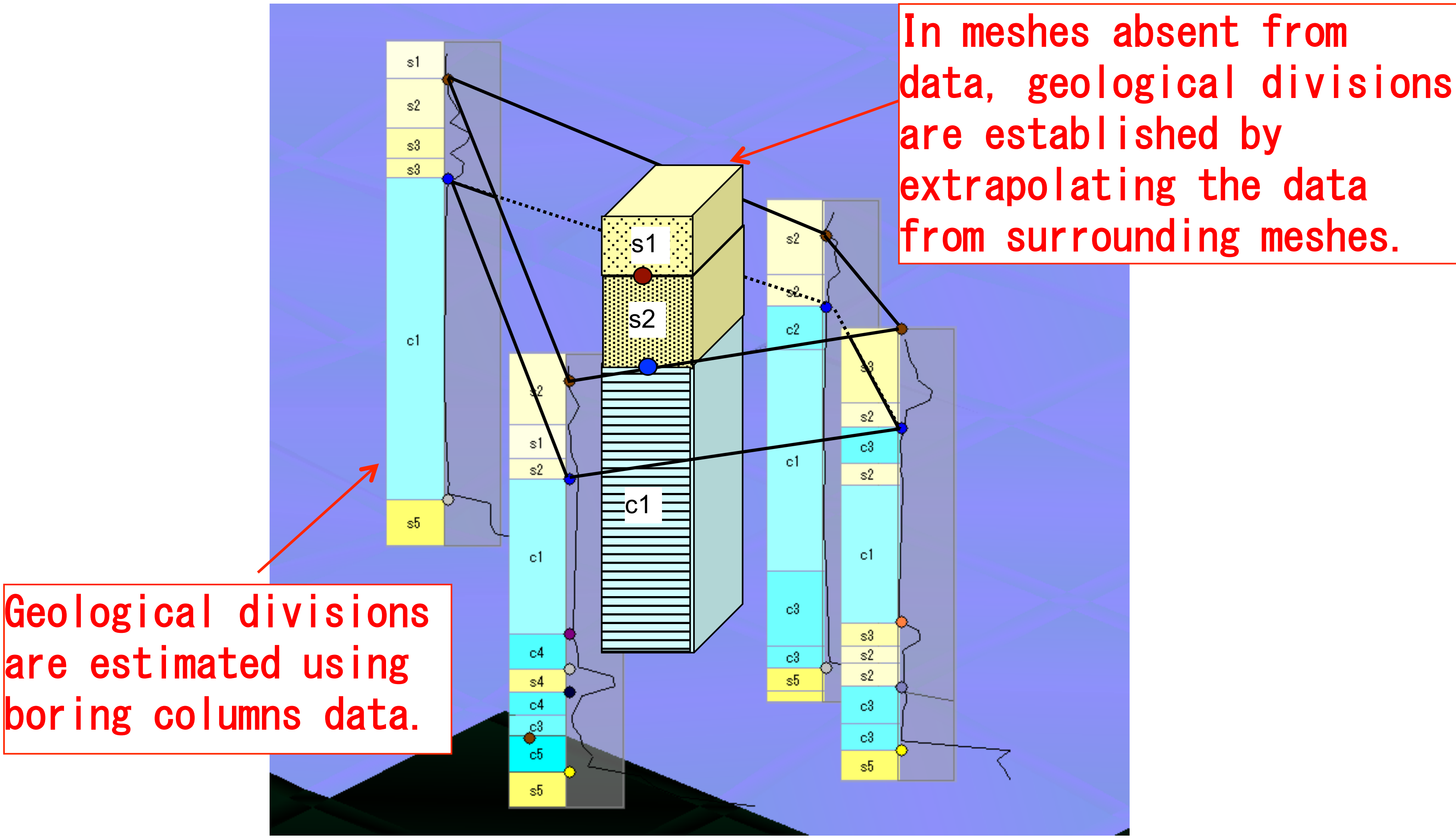
Constructing 3-Dimensional geological sturctures



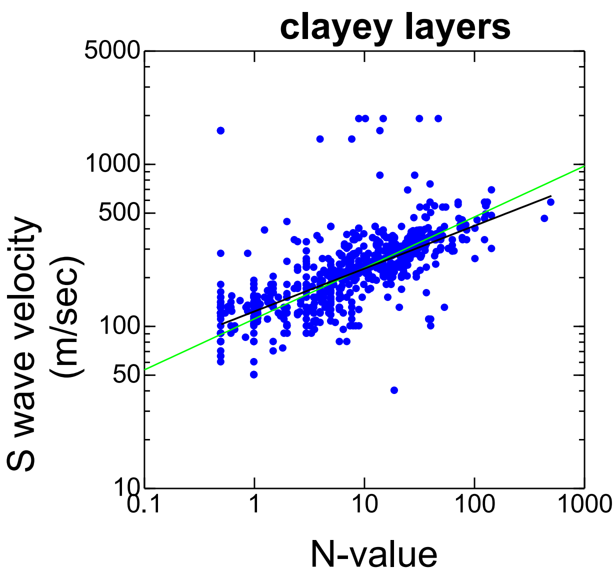


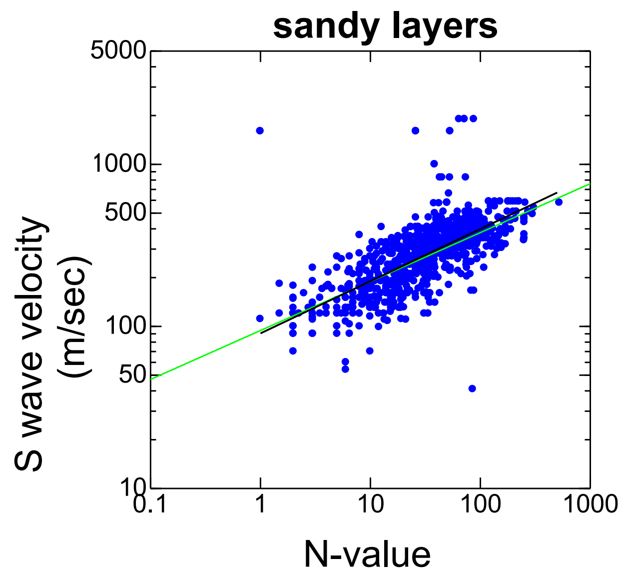
Same colored dots indicate same layer-boundaries.

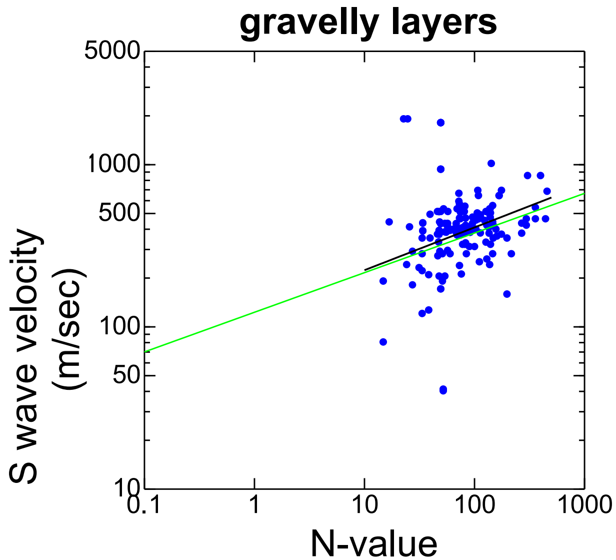
Assigning geological data to each 250m mesh



Interrelations of N-values and S-wave velocities



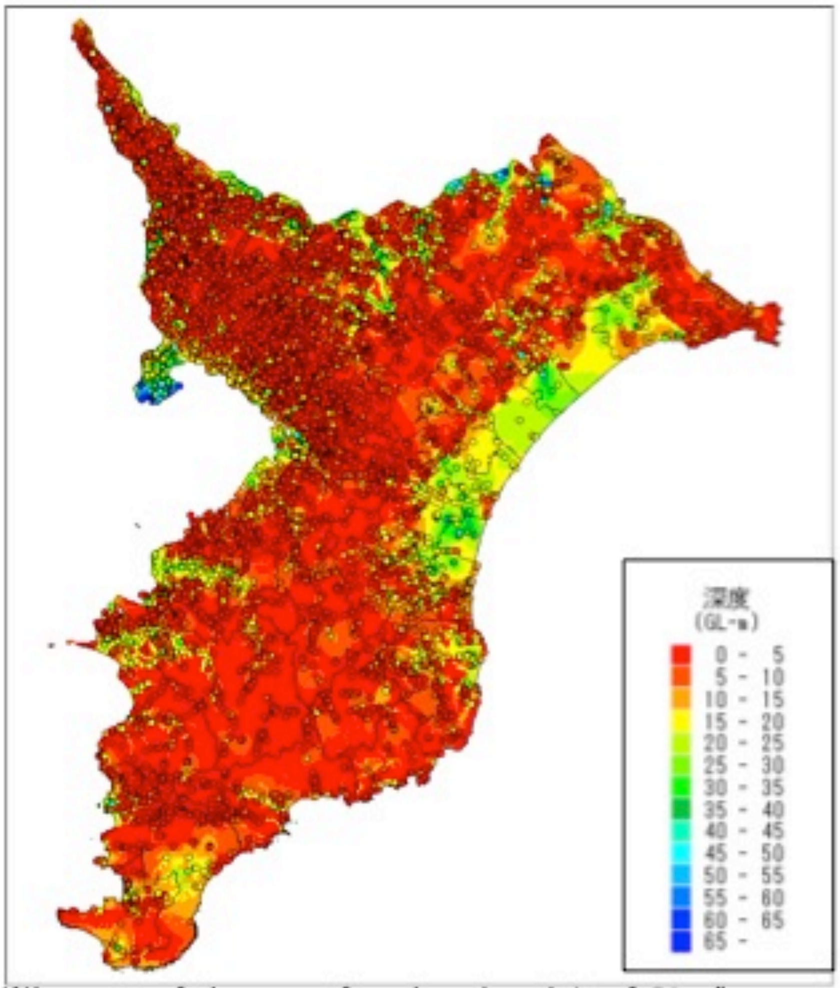




◆ shear wave velocity data by PS logging

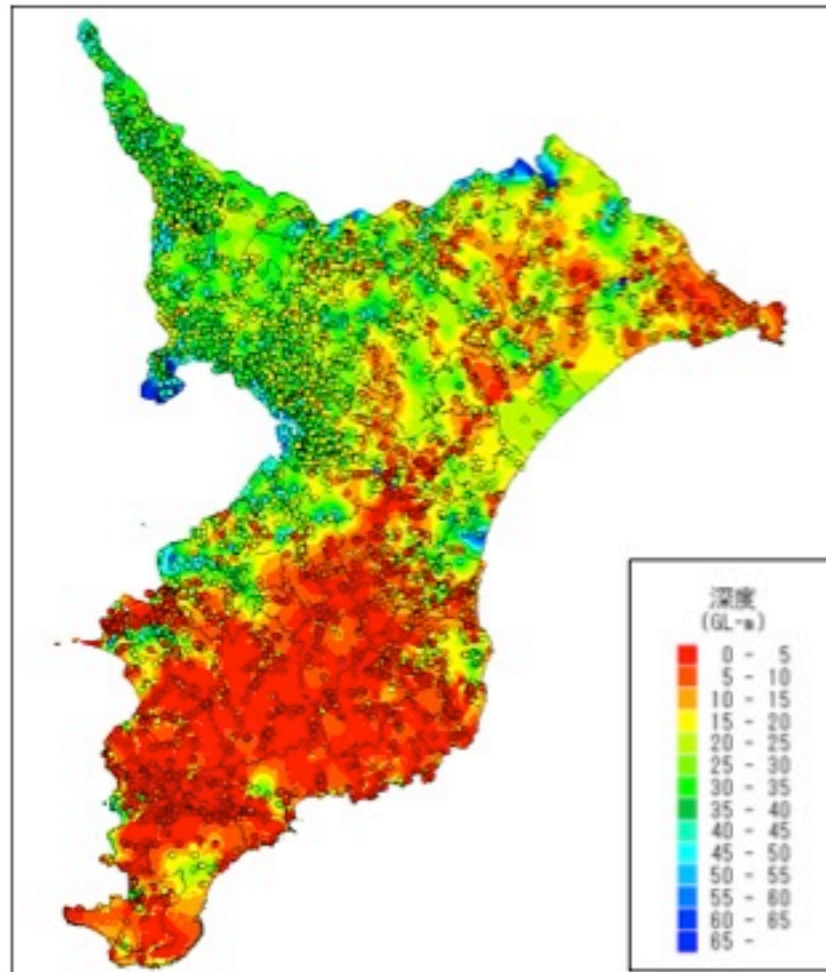
Shallow subsurface sturcture models: Depth contours of upper surfaces of layers

Holocene marine clay



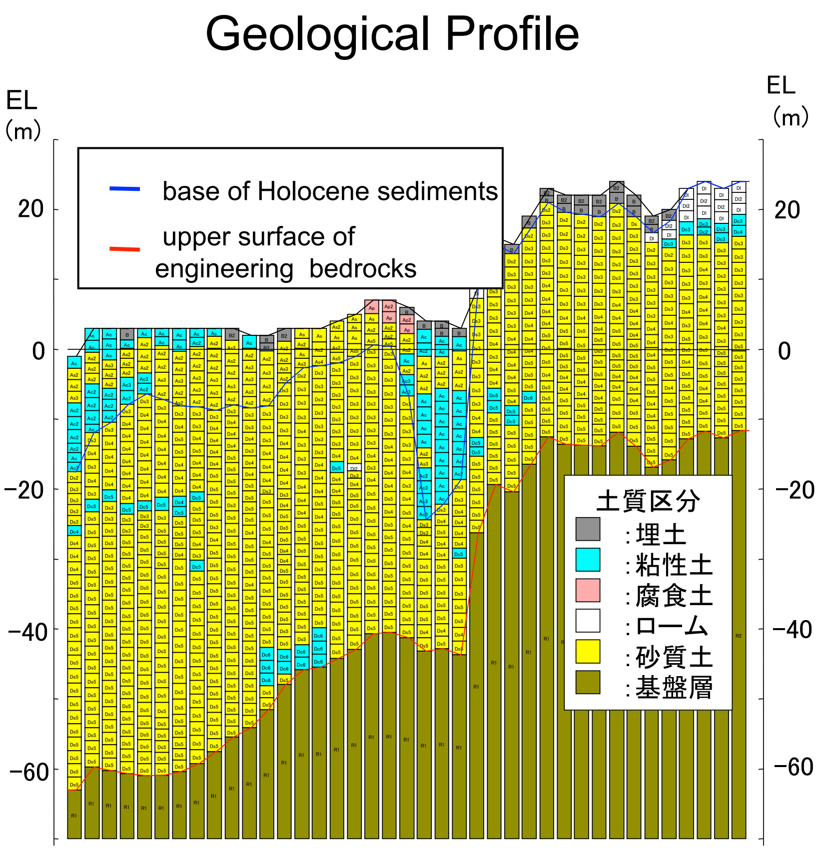
※In areas of absence of marine clay, data of "0m" are shown as dummies.

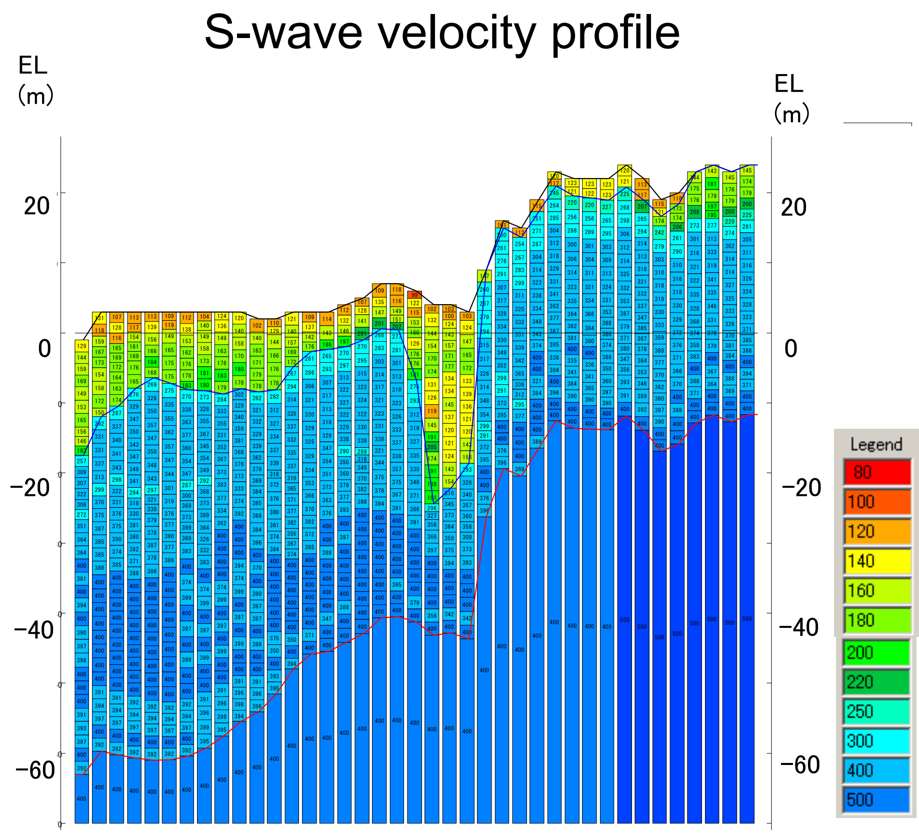
Engineering bedrocks
(almostly N-values >50)



Shallow subsurface sturcture models : Profiles of the ground

Vs(m/sec)





With Deep subsurface structure model , these Shallow ones are used for Strong-motion Evaluation （1st−order model）

Conclusions :

- Deep subsurface structure model based on geological data covers all over Japan.
- Modified model is useful to simulate strong motions caused by future earthquakes and can be downloaded from the website of "J-SHIS".
- Shallow subsurface structure model based on geological data covers Kanto and Niigata districts.
- These models are useful for Strong-motion Evaluation

Several problems :

・Deep subsurface structure model could be upgraded to more precise one based on more and more geological and geophysical exploration data.

・Deep model must be integrated with the shallow one and must be tuned by micro tremor survey data.

・Constructing shallow subsurface model is man-power consuming work, so we must developed more efficient method.

That's all.

Thank you for your attention .